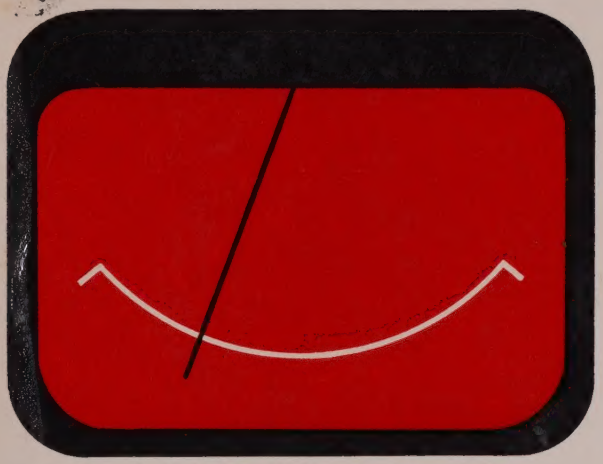
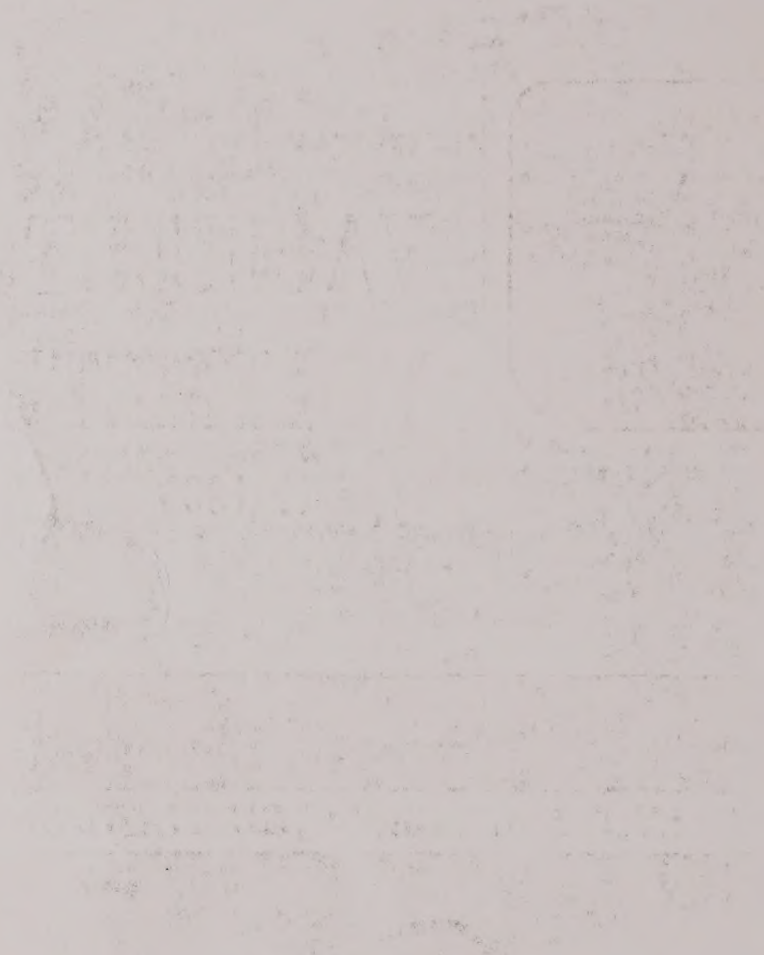


VACUUM TUBE VOLTMETER

Type TF 1300

OPERATING AND MAINTENANCE HANDBOOK

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND



OPERATING
AND
MAINTENANCE
HANDBOOK

No. OM 1300

Vacuum Tube Voltmeter

TYPE TF 1300

Serial Nos.

JA 136/001 to JA 136/300
JA 187/001 to JA 187/500
JA 298/001 to JA 298/250

MARCONI INSTRUMENTS LTD., ST. ALBANS, HERTS., ENGLAND

B.W. 5c 7/60

OM 1300
1 - 6/60

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Schedule of Parts Supplied

The complete equipment comprises the following items:—

1. One Vacuum Tube Voltmeter Type TF 1300, complete with attached mains lead, diode probe unit and d.c. leads, and with valves, etc., as under:—

Valves:	One:	Type DA90, Diode.
	Two:	Type 12AU7 (B329), Double Triodes.
	One:	Type 6X4 (U78), Full-Wave Rectifier.
Lamp:	One:	6·3-volt, 0·15-amp M.C.C. Pilot Lamp.
Stabilizers:	Two:	1·5-volt Cells, A.E. Type 15BC20.

2. One Grounding Clip Type TC 23535/3, to fit Probe Unit.

3. One Operating and Maintenance Handbook, No. OM 1300.

4. *When specially ordered:* One A.C. Multiplier Type TM 6067.

Data Summary

A.C. Measurements

RANGES: 50 mV to 100 volts in five ranges. Full-scale deflections: 1, 3, 10, 30, and 100 volts.

ACCURACY: ± 3% of f.s.d. ± 0·02 volt.

FREQUENCY RESPONSE: Typical characteristic, relative to response at 1 kc/s, is flat within:
— 1 dB at 20 c/s,
± 0·2 dB from 50 c/s to 200 Mc/s,
+ 1·5 dB at 300 Mc/s.
(See Fig. 2.2 for frequency characteristic curve.)

INPUT CONDITIONS: Shunt capacitance: approx. 4 μμF.
Resistance: approx. 5 MΩ up to 100 kc/s, 2·7 MΩ at 1 Mc/s, 0·8 MΩ at 10 Mc/s, and 50 kΩ at 100 Mc/s.
(See Fig. 2.3.)

D.C. Measurements

RANGES: 100 mV to 300 volts in five ranges. Full-scale deflections: 3, 10, 30, 100, and 300 volts.

ACCURACY: ± 2% of f.s.d.

INPUT RESISTANCE: 90 MΩ ± 5%.

Meter Zero: The meter zero is not affected by changes in the setting of the RANGE switch. A supply mains variation of 6% will cause a maximum change of 3% f.s.d. on the lowest a.c. or d.c. range; other ranges are relatively unaffected.

OVERLOAD PROTECTION: The meter is protected against serious overloads by the characteristics of the associated valve circuits.

Resistance Measurements

RANGES: 50 ohms to 5 MΩ in two ranges centred on 1 kΩ and 100 kΩ.

Power Supply: 200 to 250 volts, or 100 to 150 volts after adjusting internal link, 40 to 100 c/s, 20 watts.
Models supplied ready for immediate 100- to 150-volt use if specified at time of ordering.

Dimensions (over projections):	*Height*	*Width*	*Depth*
	10¾ in. (27·5 cm)	7¾ in. (20 cm)	6¾ in. (17·5 cm)

Weight: 9½ lb (4·3 kg)

OM 1300
1—6/60

1 Description

1.1 GENERAL

The TF 1300 Voltmeter measures a.c. voltages from 50 mV to 100 volts in the frequency range 20 c/s to 300 Mc/s, d.c. voltages from 100 mV to 300 volts, and resistances from 50 ohms to 5 MΩ. Five ranges are used for a.c. measurements, five for d.c., and two for resistance. For d.c. measurements, provision is made for reversing the meter movement, thus facilitating the measurement of d.c. voltages of unknown or changing polarity.

The meter is direct reading for d.c. as well as a.c. measurements. Zero stability is of a high order with respect to both time and mains variation, and only one zero setting is required for all a.c. or all d.c. ranges. Both a.c. and d.c. inputs are isolated from chassis.

The instrument has many applications: it is equally suitable for audio, video, r.f., and v.h.f. use on production lines, in development laboratories and in teaching establishments. The compact mechanical design is accomplished by mounting the components on the rear of the front panel, which hinges upwards for ease of servicing. Operational presets are accessible in a case-top recess which is also used for lead stowage. The recess lid hinges back to form a support that allows the instrument to be used, if required, in a sloping position.

An alternative version of the Voltmeter, Type TF 1300/1, which has a balanced a.c. probe, is also available. It allows measurement of voltages between two high-impedance points, and has a frequency range of 20 c/s to 200 Mc/s.

1.2 OPTIONAL ACCESSORIES

1.2.1 A.C. MULTIPLIER TYPE TM 6067

This auxiliary probe cap, which plugs on to the normal a.c. probe, extends the a.c. measurement range to 1000 volts r.m.s. at frequencies from 20 c/s to at least 50 Mc/s. It comprises a resistive-capacitive divider that introduces a multiplying factor of × 10, with an accuracy of better than ± 5% between 40 c/s and 10 Mc/s. It has a nominal input impedance of 5 MΩ with 5 μμF in shunt.

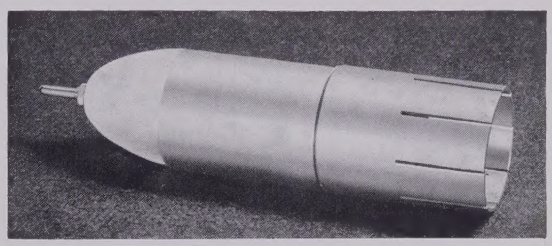


Fig. 1.1 A.C. Multiplier.

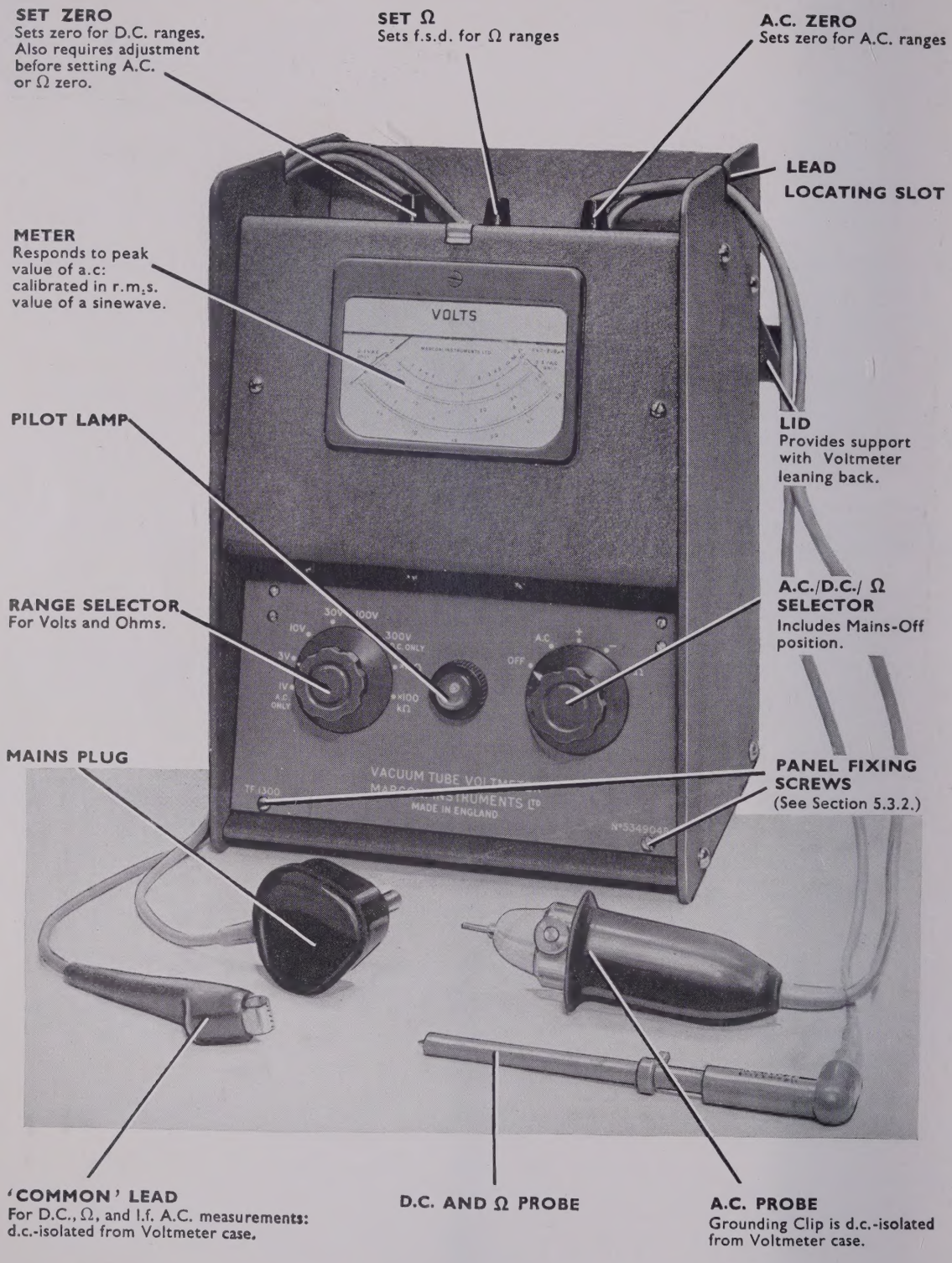

SET ZERO
Sets zero for D.C. ranges. Also requires adjustment before setting A.C. or Ω zero.
SET Ω
Sets f.s.d. for Ω ranges
A.C. ZERO
Sets zero for A.C. ranges
LEAD LOCATING SLOT
METER
Responds to peak value of a.c: calibrated in r.m.s. value of a sinewave.
VOLTS
PILOT LAMP
LID
Provides support with Voltmeter leaning back.
RANGE SELECTOR
For Volts and Ohms.
A.C./D.C./ Ω SELECTOR
Includes Mains-Off position.
MAINS PLUG
PANEL FIXING SCREWS
(See Section 5.3.2.)
'COMMON' LEAD
For D.C., Ω, and l.f. A.C. measurements: d.c.-isolated from Voltmeter case.
D.C. AND Ω PROBE
A.C. PROBE
Grounding Clip is d.c.-isolated from Voltmeter case.

Fig. 2.1 *Controls and Operating Facilities.*

2 Operation

2.1 INSTALLATION

The Voltmeter is despatched with all valves in their holders, and ready for use with 240-volt, 40- to 100-c/s supplies, unless it has been otherwise specified at the time of ordering. Adjustment can be made to suit any other supply voltage in the ranges 100 to 150 volts and 200 to 250 volts.

Check, or alter, the supply voltage setting by following the instructions given in Section 5.2.

2.2 PRELIMINARY ADJUSTMENTS

(1) Set the mechanical zero adjuster on the meter.

(2) Open the lid by lifting its front edge to disengage the spring clip above the meter. Pull out the mains lead and locate it in the slot at the top of one of the side panels.

(3) Switch on by turning the Selector switch from the OFF position. The red pilot lamp should then glow. Allow the instrument to warm up for at least 10 minutes, preferably half an hour.

With the lid hinged back to form a support, the Voltmeter may be operated in a sloping position as an alternative to the normal upright one.

2.3 A.C. MEASUREMENTS

2.3.1 PROCEDURE

When the instrument has warmed up, set zero as follows:—

(1) Turn the Selector switches to the 3V " + " or " — " d.c. range and, with the D.C./Ω probe and the COMMON lead temporarily connected together, adjust the SET ZERO control to bring the meter pointer to zero.

(2) Then select the 1V A.C. range and, with the a.c. probe needle and the Grounding Clip temporarily connected together, adjust the A.C. ZERO control to again bring the meter pointer to zero. This control is fairly sluggish and the meter deflection should be allowed time to stabilize after each adjustment.

Any subsequent small variations in a.c. zero may be offset by means of the SET ZERO control unless it is particularly required to keep the zero setting for the d.c. ranges undisturbed; in this case, use the A.C. ZERO control.

If the zero setting appears to be affected by supply voltage variations refer to Section 5.8.4— Stabilization of A.C. Zero.

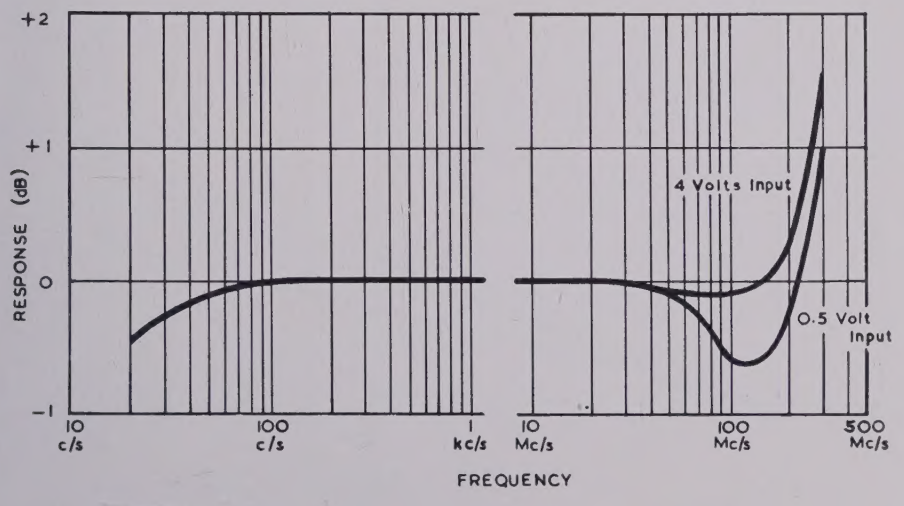


Fig. 2.2 Typical Frequency Characteristic of A.C. Probe.

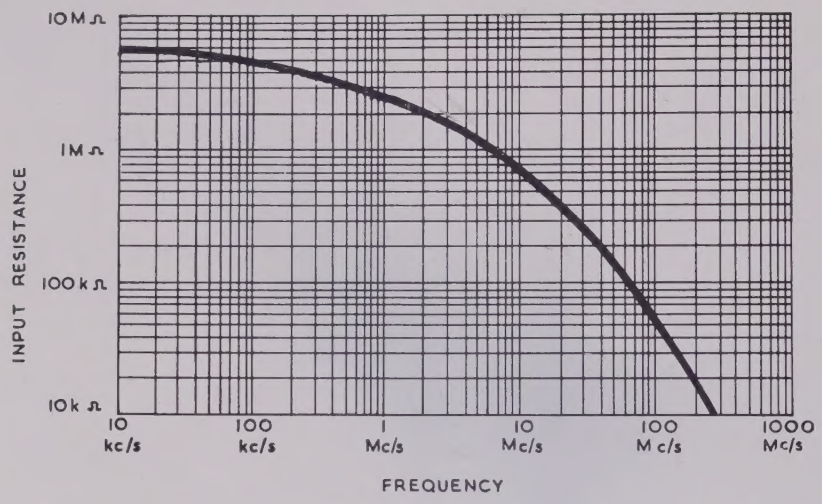


Fig. 2.3 Variation of Probe Input Resistance with Frequency.

Having set zero, make the measurement as follows:—

(1) Select the A.C. range appropriate to the expected level of voltage to be measured.

If the level of the voltage to be measured is unknown always select the least sensitive range, i.e. 100 volts, before connecting the Voltmeter to the equipment under test. (The 300-volt range is for d.c. measurements only.)

(2) Connect the A.C. probe to the voltage source (for details see Section 2.3.2), and read the voltage from the appropriate scale. Readings should be taken from one or other of the bottom two meter scales except when the 1-volt or 3-volt range has been selected; for these ranges use the special meter scales marked 0—3V A.C. ONLY.

2.3.2 CONNECTIONS

The meter is calibrated in terms of the voltage that exists between the base of the probe needle (Hi) and the ground band of the probe case (Lo). The probe casing is a.c. coupled to the Voltmeter chassis, and directly coupled to the COMMON lead. For l.f. measurements the COMMON lead can be used as the " Lo " connection, but for r.f. measurements the " Lo " connection should be made by a fly lead via the Grounding Clip. The higher the frequency, the more important it is to keep the lead as short as possible.

Approximate measurements at r.f. may be made without use of either earth clip or COMMON lead; the " Lo " a.c. earth return is made automatically via the decoupling capacitor to chassis in the

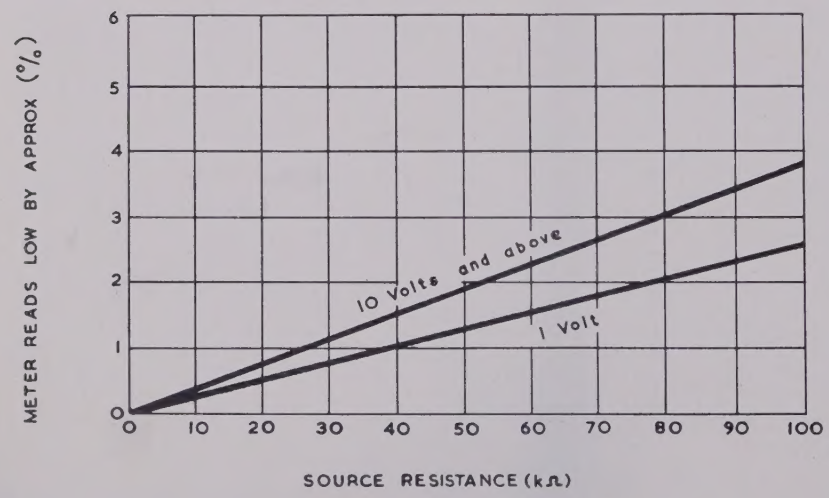


Fig. 2.4 Reading Error at A.F. as a Function of Source Resistance.

Voltmeter or by self-capacitance between the probe casing and the chassis of the equipment under test.

Since the " Lo " input is d.c. isolated from the Voltmeter chassis by a 22-MΩ resistor, the point to which it is to be connected need not be at earth potential; however, it should preferably have a low impedance to earth. This will prevent hum being introduced into the test circuit and will also prevent errors due to the building-up of a d.c. potential across the decoupling capacitor in the Voltmeter.

2.3.3 PROBE INPUT IMPEDANCE

The probe presents to the source a capacitance of approximately 4 μμF, and a shunt resistance which varies with frequency. This variation is shown in Fig. 2.3.

2.3.4 INDICATION

The meter is calibrated to read the r.m.s. value of a sinusoidal signal.

When appreciable distortion is present in the signal, the meter reading differs from the r.m.s. by an amount that depends on the magnitude and phase of the harmonics. Where one harmonic predominates, the percentage difference in either direction can be as high as the percentage distortion.

On the higher ranges, the peak value of both simple and complex waveforms is obtained by multiplying the meter reading by 1·414.

2.3.5 VOLTAGE LIMITATIONS

The peak voltage applied between the " Hi " and " Lo " probe connections must not exceed 450 volts. Allowance must be made for this fact when measuring pulsed signals or a.c. superimposed on d.c.; in the latter case, the peak voltage is given by the d.c. plus the peak a.c.

The peak voltage between the " Lo " connection and earth must not exceed 250 volts a.c. or 350 volts d.c.

2.3.6 ERROR DUE TO HIGH SOURCE RESISTANCE

When measuring voltages across a high-resistance source, the meter reads low as a result of the peak clipping effect. The degree of reading error at audio frequencies is shown graphically in Fig. 2.4. The error increases at higher frequencies, but the effect is of less significance in view of the lower source resistances that are likely to be encountered.

Note that the value of source resistance is the total a.c. resistance across the probe connections, taking into account any parallel paths.

2.4 D.C. MEASUREMENTS

2.4.1 PROCEDURE

When the instrument has warmed up, first set zero as follows:—

(1) Turn the Selector switches to the 3V " + " or " — " d.c. range and, with the D.C./Ω probe and COMMON lead temporarily connected together, adjust the SET ZERO control to bring the meter pointer to zero.

Having set zero, make the measurement as follows:—

(1) Select the range appropriate to the expected level and polarity of the voltage to be measured. If the level of the voltage to be measured is unknown, always select the least sensitive range, i.e. 300 volts, before connecting the Voltmeter to the source under test.

(2) Connect the D.C./Ω probe and COMMON lead to the voltage source (for details see Section 2.4.2) and read the voltage on the appropriate meter scale. Readings should be taken from one or other of the bottom pair of meter scales as appropriate to the setting of the left-hand Selector switch.

The peak voltage between the COMMON lead and earth must not exceed 250 volts a.c. or 350 volts d.c.

2.4.2 CONNECTIONS

The TF 1300 will measure unbalanced voltages up to 300 volts d.c. Connection to the voltage source to be measured is made by means of the D.C./Ω probe and the COMMON lead. Since the COMMON lead is isolated from the Voltmeter chassis by a resistance of 22 MΩ it does not necessarily have to be connected to earth on the equipment under test; it must, however, always be connected to the point nearer to earth potential to prevent the input resistance being shunted by the 22-MΩ isolating resistor.

It is also advisable to connect the COMMON lead to a low-impedance point on the unit under test; this prevents hum being introduced into the test circuit and also prevents measurement errors due to the building up of a d.c. potential across the decoupling capacitor which connects the Voltmeter COMMON line to chassis.

Use the " + " position of the right-hand Selector switch when the D.C./Ω lead is connected to the more positive point, and the " — " position when connected to the more negative.

2.4.3 INPUT IMPEDANCE

The input resistance, that is between the probe and the COMMON line, is 90 MΩ; the COMMON line itself is isolated from the Voltmeter chassis by a resistance of 22 MΩ in parallel with a capacitance of 0·01 μF.

2.5 RESISTANCE MEASUREMENTS

2.5.1 PROCEDURE

When the instrument has warmed up, first set zero as follows:—

(1) Turn the right-hand Selector switch to " Ω," and the left-hand switch to " × 1 kΩ."

(2) Temporarily connect the D.C./Ω probe and COMMON lead together and adjust the SET ZERO control to bring the meter pointer to zero.

(3) Open-circuit the D.C./Ω probe and COMMON lead and adjust the SET Ω control to bring the meter pointer to the full-scale infinity mark.

Having set zero make the measurement as follows:—

(1) Connect the D.C./Ω probe and COMMON lead across the unknown resistance (for details see Section 2.5.2) and set the left-hand Selector switch to obtain a convenient meter deflection.

The resistance value is then the product of the meter indication on the top meter scale and the multiplying factor indicated by the left-hand Selector switch.

2.5.2 CONNECTIONS

The TF 1300 measures resistances in the range 50 ohms to 5 MΩ; connection to the unknown resistance is made by means of the D.C./Ω probe and COMMON lead. The COMMON lead is isolated from the Voltmeter chassis by a resistance of 22 MΩ and should be connected to the side of the unknown having the lower resistance to earth.

When the unknown is not isolated but forms part of a circuit, it is necessary to switch off any power supplies to this circuit.

2.6 USE OF OPTIONAL ACCESSORIES

2.6.1 A.C. MULTIPLIER TYPE TM 6067

The Multiplier extends the a.c. measurement range of the Voltmeter to 1000 volts r.m.s. at frequencies from 20 c/s to at least 50 Mc/s (see Section 1.2.1).

Insert the a.c. probe into the Multiplier, taking care that the probe needle engages correctly in its mating socket. The " Lo " connection can be made by fitting the normal Grounding Clip to the Multiplier. The general measuring procedure is then similar to that described in Section 2.3, the unknown voltage being determined by multiplying the Voltmeter indication by 10.

The Multiplier must not be used to measure voltages with a peak value greater than 1·4 kV; when measuring a.c. voltages superimposed on d.c., the peak value of the a.c. voltage plus the standing d.c. or mean voltage must not exceed 1·4 kV.

3 Operational Summary

Once the user is familiar with the principles and techniques of operation detailed in Section 2, the following abridged instructions may be found convenient.

BEFORE SWITCHING ON

(1) Check that the power transformer is correctly adjusted.

(2) Set the mechanical zero of the meter.

A.C.

Setting Zero

Set Selector switches to 3V " + " or " — " d.c. Connect D.C./Ω probe to COMMON lead and adjust SET ZERO. Then select 1V A.C. range, and connect a.c. probe tip to Grounding Clip; adjust A.C. ZERO.

Measurements

Turn Selector switches to appropriate A.C. range. Connect probe to voltage source: use short fly-lead attached to Grounding Clip for " Lo " connection. Meter reads r.m.s. of sinewaves. Peak voltage between " Hi " and " Lo " points must not exceed 450 volts; that between " Lo " and earth must not exceed 250 volts a.c. or 350 volts d.c.

D.C.

Setting Zero

Set the Selector switches to 3V " + " or " — " d.c. Connect D.C./Ω probe to COMMON lead and adjust SET ZERO.

Measurements

Select appropriate range. Connect Voltmeter to voltage being measured by D.C./Ω probe and COMMON lead, with COMMON lead on point nearer earth potential.

Peak voltage between COMMON lead and earth must not exceed 250 volts a.c. or 350 volts d.c.

RESISTANCE

Setting Zero

Set Selector switches to " Ω " and " × 1 kΩ." Connect D.C./Ω probe and COMMON lead together and adjust SET ZERO to bring meter to zero. Open-circuit D.C./Ω probe and COMMON lead and adjust SET Ω for infinity on meter.

Measurements

Connect D.C./Ω probe and COMMON lead across unknown resistance and set left-hand Selector to obtain convenient deflection.

4 Technical Description

The following detailed description is intended to be read in conjunction with the complete Circuit Diagram, Fig. 8.1.

4.1 D.C. MEASURING CIRCUIT

The d.c. section of the Voltmeter consists basically of two double-triodes connected in a four-arm bridge circuit with a meter as an out-of-balance indicator. The lower pair of triodes—V3—act as high-resistance cathode-loads to the other pair—V2— which act as two cathode followers. The unknown voltage to be measured is, in effect, applied between the two cathode-follower grids, with the meter and its associate range resistors connected between the cathodes.

In order to achieve good gain stability the cathode followers require load resistances of a high value. The use of resistors for this purpose would result in a large d.c. voltage drop requiring a large power supply. Triodes are therefore used as cathode loads since their effective " r_a " gives the required high load resistance with a much smaller order of power supply. An additional facility of triodes used in this fashion is the easy control of their working conditions in order to balance the bridge for zero meter deflection with no input signal. This is attained by adjusting the grid potential of one triode with respect to that of the other; potentiometer RV9, an internal preset giving the coarse adjustment, and RV10, the SET ZERO control giving the fine adjustment.

D.C. voltages are measured using the D.C./Ω probe and COMMON lead. The unknown voltage is fed, via the probe, to a potential divider network consisting of R5, R6, and R7. These, combined, give a total input resistance of 90 MΩ.

For the lower ranges one-third of the input voltage is applied to the bridge circuit, the meter sensitivity being altered for each range by the resistors associated with switch wafer S1e. For the 300V D.C. range the input to the bridge is further reduced to one-ninth of that at the probe tip.

The COMMON lead is isolated from the Voltmeter chassis by a 0·01-μF capacitor—C2, with a 22-MΩ resistor—R4—in shunt. This COMMON line is also connected to a tapping on the h.t. potential divider which determines the no-signal h.t. voltage across the cathode followers. The valve characteristics and the design of the associated circuits provide automatic overload protection for the meter.

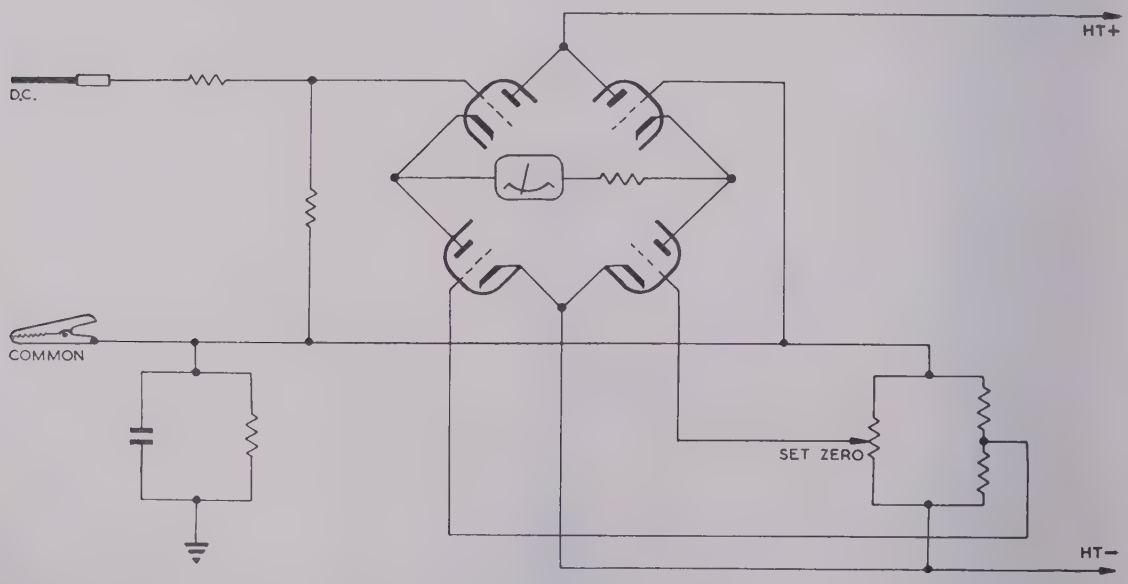


Fig. 4.1 *Basic D.C. Measuring Circuit.*

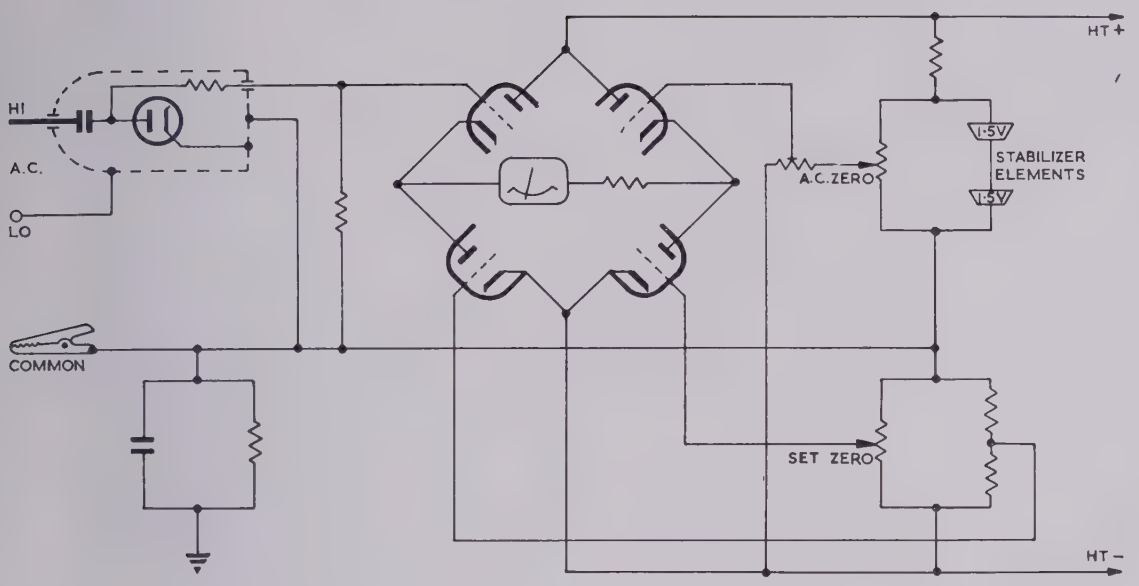


Fig. 4.2 Basic A.C. Measuring Circuit.

4.2 A.C. MEASURING CIRCUIT

The unknown a.c. voltage is converted to a convenient d.c. voltage by the A.C. diode probe unit so that it can be applied to the basic measuring circuit. A shunt connected diode circuit is used with a 0·01-μF input isolating capacitor and a diode load of 66 MΩ. The unavoidable capacitance to ground, introduced by the lead connecting the probe to the main Voltmeter circuit, is isolated from the circuit under test by mounting part of the diode load—7·5 MΩ—close to the tip of the probe. Thus the shunt capacitance, presented by the probe to the test circuit, is kept as low as possible, being approximately 4 μμF.

The input resistance of the probe at the higher frequencies is mainly dependent on the losses associated with the valve and its holder. The result is that the input resistance—or effective damping resistance—of the probe drops from about 5 MΩ at 100 kc/s to about 50 kΩ at 100 Mc/s (see Fig. 2.3).

The probe diode conducts on positive peaks, with the result that a negative d.c. voltage is applied to the bridge circuit, via switch wafer S2ab. The meter is calibrated in the equivalent r.m.s. voltage of a sinusoidal input; its sensitivity, for the A.C. ranges, is altered by the resistors associated with switch wafer S1f.

The splash—or initial velocity—current of the diode causes a standing voltage to be present at the grid of the input cathode follower. In order to back off this voltage so that the meter remains at zero when switching the Voltmeter from D.C. to A.C. an unusual method is used. Two 1·5-volt nickel-cadmium stabilizer cells—VS1 and VS2—are connected in series with a bleeder system across the h.t. supply. These are not storage cells but they act in a similar way to an accumulator on charge in that they maintain a constant p.d. over a relatively wide range of input current. Since the diode splash voltage will vary with mains fluctuations the backing-off voltage should vary in a corresponding manner. This is achieved by adding a portion of unstabilized h.t. voltage to the stabilized voltage to give the required slope. The A.C. ZERO—RV8—is adjusted to give a tapping off the stabilizer voltage corresponding to the average value of the probe splash voltage. An internal preset—RV7—adjusts the proportion of unstabilized h.t. voltage. To avoid mains surges upsetting the zero balance, a long time constant is introduced into the backing-off supply, by means of R19 and C4, to match the thermal delay of the probe diode.

When the Voltmeter is switched to a d.c. range, the output of the probe and the backing-off supply are disconnected from the bridge circuit, but the heater supply to the diode is maintained so that delay is avoided when switching from D.C. to A.C.

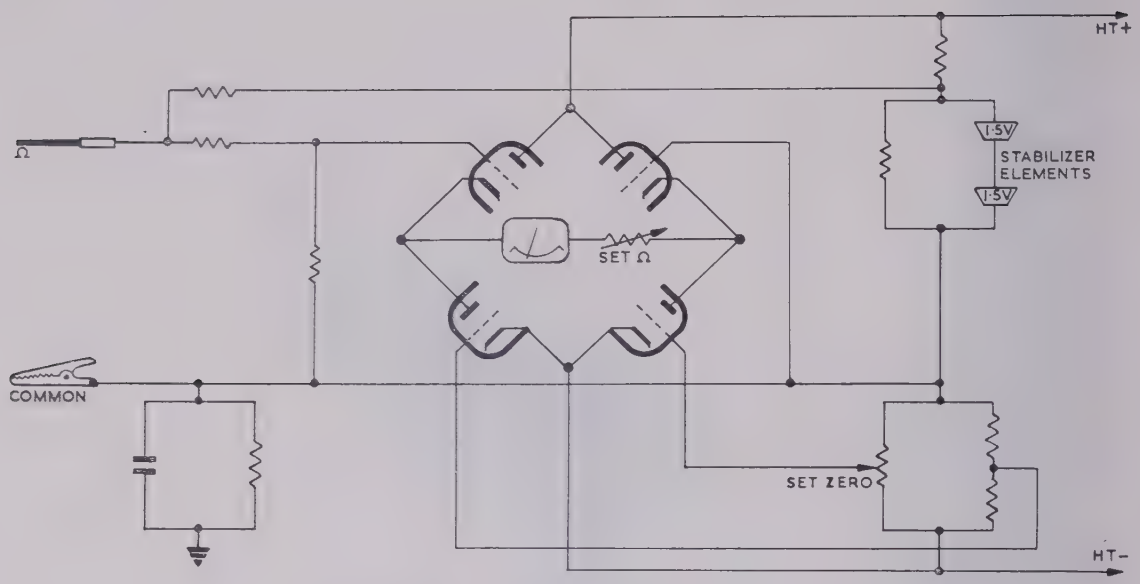


Fig. 4.3 *Basic Resistance Measuring Circuit.*

4.3 RESISTANCE MEASURING CIRCUIT

Two resistance measuring ranges are provided giving mid-scale values of 1 kΩ and 100 kΩ. The constant voltage of low source resistance used is that developed across the two 1·5-volt stabilizer cells. The unknown resistance to be measured is placed in series with a close-tolerance standard resistor—R20 or R21—and the 3-volt stabilized voltage. The voltage drop across the unknown resistance is measured with the normal d.c. measuring circuit.

Before making a resistance measurement, therefore, firstly the d.c. measuring bridge is balanced, by adjusting the SET ZERO control, RV10, and then the meter sensitivity is adjusted, by the SET Ω control—RV4—to give full-scale deflection. This is with the D.C./Ω probe and COMMON lead short circuited, i.e. zero resistance, and open circuited, i.e. infinite resistance, respectively.

4.4 POWER UNIT

The Voltmeter has a built-in power supply to provide the l.t. voltage for the valve heaters and h.t. voltage for the bridge circuit. As the a.c. probe diode has a 1·4-volt heater a resistor—R31—is used to drop the 6·3-volt l.t. supply to the required level. Tappings on the mains transformer primary windings allow operation from any 40- to 100-c/s supply within the ranges 100 to 150 volts and 200 to 250 volts.

5 Maintenance

5.1 GENERAL

It is strongly recommended that the user should become familiar with the principles described in Section 4 before commencing the adjustment or replacement of component parts of the instrument.

The Circuit Diagram shows all the electrical components contained in the instrument and also gives their values. The descriptions of these components—their types, tolerances, ratings, etc.—are given in the Spares Ordering Schedule; the Schedule also lists certain selected mechanical components.

The physical locations of the electrical components are shown in the Component Layout Illustrations.

5.2 MAINS INPUT ARRANGEMENTS

The instrument can be adjusted to operate from any 40- to 100-c/s supply within the ranges 100 to 150 volts and 200 to 250 volts.

The mains transformer has a double-wound primary with its two tapped sections connected in series for 200- to 250-volt operation or in series-parallel for 100- to 150-volt operation.

The high (200- to 250-volt) or low (100- to 150-volt) range is selected by links on the coil of the transformer. Selection of intermediate voltages within either range is made by means of fly leads on the transformer tags. These tags are common to both ranges and are, therefore, designated with two voltages; the applicable voltage depends on the position of the range links.

To obtain access to the mains transformer, remove the two front panel screws (see Fig. 2.1), slacken the top and bottom screws near the front edge of each side panel, and swing the panel assembly outwards and upwards from the bottom.

Compare the transformer connections with the diagrams opposite.

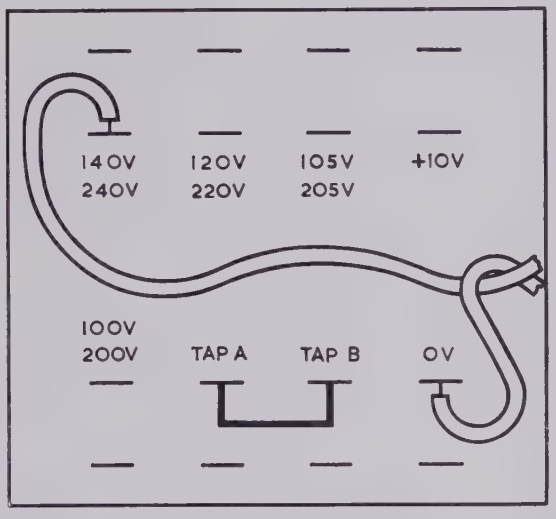


Fig. 5.1 240-*volt Connections.*

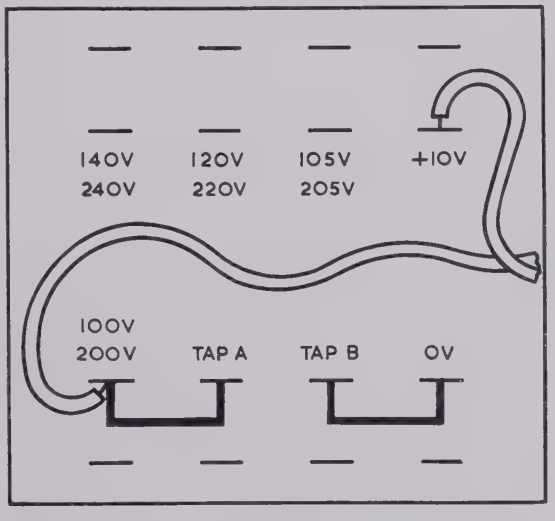


Fig. 5.2 110-*volt Connections.*

(a) 200- to 250-volt range

Only one fixed link is used, as shown; this connects the two primary windings in series. One fly lead must be connected to either " 0 " or " 10 " and the other lead to the tag whose designation, added to 0 or 10 as appropriate, matches the supply voltage.

(b) 100- to 150-volt range

Two fixed links are used, as shown; these connect the two primary windings in parallel. One fly lead must be connected to either " 0 " or " 10 " and the other lead to the tag whose designation, added to 0 or 10 as appropriate, matches the supply voltage.

5.3 ACCESS TO COMPONENTS

5.3.1 REMOVAL OF METER SURROUND

To obtain access to the preset components, valve bases, and associated wiring:—

(1) Lay the instrument on its back, or support it in the sloping position by means of the recess lid.

(2) Extract the two 4-BA screws, one each side of the meter, and remove the meter surround.

Caution: *The meter is held in position only by this surround; take care that the meter does not fall out if the instrument is stood upright again.*

5.3.2 ACCESS TO INTERNAL COMPONENTS

To gain access to the interior of the instrument:—

(1) Slacken, but do not remove, the top and bottom screws near the front edge of each side panel.

(2) Remove the two 4-BA screws at the bottom of the front panel (see Fig. 2.1).

(3) Having checked that all leads are free of the locating slots in the top of the side panels, swing the complete front panel assembly outwards and upwards from the bottom. The front panel is pivoted about the upper side-panel screws.

5.3.3 DISMANTLING THE A.C. PROBE

To gain access to the components within the a.c. probe assembly (see Fig. 6.4):—

(1) Remove the Grounding Clip. Hold the probe cap pointing downwards and separate the two halves of the probe by unscrewing the main casing from the probe-cap ferrule.

(2) The ceramic disk capacitor, C1, is retained in the probe cap with silicone compound, Midland Silicones type MSA.

In the assembled probe the capacitor is held between two domed contacts, one moulded in the probe cap, the other formed by the anode connector for the diode.

(3) Resistor R1 is located in the central hole of the valve holder. One end is soldered to the anode domed contact and the other passes through the unused pin-retaining slit in the holder.

To reassemble the probe unit:—

(1) Place the disk capacitor so that it sits centrally on the domed contact in the probe cap.

(2) Insert the valve holder into the probe cap ferrule.

(3) Hold the ferrule and screw the probe case on to it.

5.4 WORKING VOLTAGES

The voltages given in this section for guidance when servicing the instrument were obtained from a representative TF 1300; the Voltmeter used for making the measurements was an Avometer Model 8, which has a resistance of 20 000 ohms per volt.

Measurements were made with the mains transformer tapping set to 240 volts and using a 240-volt supply.

5.4.1 POWER SUPPLY VOLTAGES

TABLE 1

Supply	*Measured Between*	*Voltage*
H.T. a.c.	H.T. 'A' and 'B' tags on T1	320 V a.c.
L.T. a.c.	L.T. tags on T1	6·3 V a.c.
H.T. d.c.	Across C5	370 V d.c.

5.4.2 VALVE ELECTRODE VOLTAGES

The table below shows d.c. electrode voltages with respect to chassis. These are given for guidance in servicing the instrument; between individual instruments some variation in electrode voltages may be expected due to normal tolerances of valve performance and component values.

TABLE 2

Valve No.	*Anode Volts d.c.*	*Grid Volts d.c.*	*Cathode Volts d.c.*
V2a	125	—	5·0
V2b	125	—	5·0
V3a	5·0	—135	—130
V3b	5·0	—135	—130

5.5 REPLACEMENT OF VALVES

With the Voltmeter opened to reveal the underside of the front panel, as described in Section 5.3.2, all valves, except the probe diode, are immediately accessible. To obtain access to the probe diode, carry out the procedure described in Section 5.3.3.

Valves may normally be replaced without special selection, although in certain cases replacement may necessitate some readjustment of associated preset components. Since the two valves of a double-triode are rarely exactly similar it may be necessary to select valves for V2 in order to obtain good d.c. zero stability; valves found unsuitable may be used in the V3 position where the circuit is less susceptible to slight differences in valve characteristics.

With regard to zero stability it is advisable to age new valves at their normal working voltage for at least 72 hours before use; this does not apply to the rectifier V4.

TABLE 3

Any valve which becomes faulty should preferably be replaced by a valve of the type originally supplied in the instrument. If this is not possible, the additional data given by the table may be used as a guide to suitable alternatives.

Valve	*Type*	*Base*	*British Commercial Equivalent*	*British Services Equivalent*	*U.S. Equivalent*
V1	Mullard DA90 Diode	a	1A3 1D13	CV753	1A3
V2 **V3**	Brimar 12AU7 Double Triode	b	B329 ECC82 M8136† 6067† E2163	CV491	12AU7
V4	Brimar 6X4 Full-wave rectifier	c	U78 EZ90	CV493	6X4

† *High-reliability type.*

a

b

c

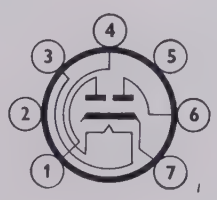


Table 4 lists those valves whose replacement is more likely to involve some readjustment and indicates the appropriate realignment procedure.

TABLE 4

Valve No.	*Check or Readjust*	*Section Describing Readjustment*
V1	A.C. zero stability	5.8.4
	A.C. accuracy	5.8.7
V2, V3	Complete instrument alignment	5.8.3 to 5.8.5

5.6 REPLACEMENT OF VOLTAGE STABILIZER CELLS

The two voltage stabilizer cells, VS1 and VS2, are mounted on the rear wafer of switch S2/S3. These are not storage cells and hence are not subject to discharge. They have an average life expectancy of 10 000 working hours and, therefore, will seldom require replacement; should this become necessary, the following points should be borne in mind:—

(*a*) Note the connections of the existing cells before removal; the positive lead is marked with a red spot and is the lead that is attached to the smaller diameter plate of the cell.

(*b*) Reconnect the replacement cells, observing the correct polarity.

(*c*) When resoldering the connections, use a thermal shunt on the cell lead to prevent damage to the main body of the cell.

5.7 PRESET COMPONENTS

During the factory calibration of the instrument, certain of its performance characteristics are brought within fine limits by means of preset components. Following the replacement or aging of certain fixed components, it may become necessary to repeat the calibration procedure by which the presets were adjusted.

Five of the seven preset potentiometers, those mounted on flat bakelite strip, have their sliders fixed after adjustment by a small amount of polystyrene cement. No attempt should be made to move the sliders before dissolving the cement with a drop of acetone or other suitable solvent.

All preset potentiometers are immediately accessible on removal of the meter surround—see cautionary note in Section 5.3.1; their relative positions and circuit references are shown in Fig. 6.1.

TABLE 5

Preset Component	*Section Describing Adjustment*	*Preset Component*	*Section Describing Adjustment*
RV1	5.8.5	RV6	5.8.6
RV2	5.8.5	RV7	5.8.4
RV3	5.8.6	RV9	5.8.3
RV5	5.8.5		

Section 5.8 gives a range of tests by which the main points of performance of the instrument can be checked; this section also deals with the adjustment of the preset potentiometers. Table 5 lists the circuit references of these components, together with the numbers of the sections in which their adjustment is described. The procedure referred to should also, of course, be carried out in the event of replacement of any of these components.

5.8 SCHEDULE OF TESTS

The following information is based on extracts from the internal Factory Test Schedule.

5.8.1 APPARATUS REQUIRED

(a) 750-volt Insulation Tester.

(b) Variable mains transformer, e.g. Variac.

(c) Source of d.c. voltage, standardized to within $\pm$ 0·5% at 3, 10, 30, 100, and 300 volts.

(d) Resistance Bridge, measuring up to 90 MΩ; Marconi Type TF 868B or TF 936.

(e) Source of 1000-c/s undistorted sinusoidal a.c. voltage standardized to within $\pm$ 0·5% at 1-, 3-, 10-, 30-, and 100-volts r.m.s.

(f) Circuit Magnification Meter (or Meters) tunable to frequencies up to 100 Mc/s; Marconi Type TF 329 (Series) (to 50 Mc/s), TF 886 (Series) and TF 1245, with associated resonating inductors.

(g) Oscillator, covering the range 25 c/s to 10 Mc/s; Marconi Type TF 885A/1 and TF 1370.

(h) Signal Generator, covering the range 10 to 300 Mc/s; Marconi Type TF 801 (Series).

(i) Valve Voltmeter, standardized; Marconi Type TF 428 (Series), TF 1300 or TF 1041 (Series).

(j) Crystal Voltmeter, covering the range 10 to 300 Mc/s; Marconi Type TF 1262.

5.8.2 INSULATION (*Apparatus required: Item a*)

Measure the insulation resistance between chassis and each " live " pin of the mains supply plug, the right-hand Selector switch being at any position other than OFF. The reading should normally be greater than 40 MΩ.

5.8.3 ADJUSTMENT OF D.C. ZERO

(*Apparatus required: Item b*)

Meter zero on the d.c. ranges is adjusted by means of preset potentiometer RV9 and the SET ZERO control.

RV9 is adjusted as follows:—

(1) Check the mechanical zero setting of the meter with the mains supply OFF.
(2) Connect the Voltmeter to the mains supply via the variable mains transformer.
(3) Using the variable mains transformer adjust the mains supply voltage to exactly the value indicated by the mains transformer primary connections.
(4) Connect the D.C./Ω probe and COMMON lead together.
(5) Set the Voltmeter Selector switches to the 3V " + " d.c. range.
(6) Turn the SET ZERO control to its mid position and, if necessary, adjust preset potentiometer RV9 to bring the meter pointer to zero.
(7) Check that the meter pointer remains at zero when the right-hand Selector switch is set to " — " d.c., and at all the voltage range positions of the left-hand Selector switch.
(8) Vary the mains voltage by ± 6% and check that the meter reading does not change by more than ± 3% of full-scale deflection.

5.8.4 ADJUSTMENT AND STABILIZATION OF A.C. ZERO

(*Apparatus required: Item b*)

On the a.c. ranges, meter-zero is adjusted, and stabilized for variations in mains supply voltage, by means of preset potentiometer RV7 and the A.C. ZERO control.

(1) Check the mechanical zero setting of the Voltmeter.
(2) Short-circuit the 22-MΩ resistor, R19, located adjacent to RV7 on the same tag board.
(3) Connect the Voltmeter to the mains supply via the variable mains transformer.
(4) Using the variable mains transformer, adjust the mains supply voltage to exactly the value indicated by the mains transformer connections.
(5) Connect the D.C./Ω probe to the COMMON lead and set the Voltmeter Selector switches to the 3V " + " d.c. range; adjust the SET ZERO control to bring the meter pointer to zero.
(6) Connect the A.C. probe tip to the COMMON lead and set the Selector switches to the 1V A.C. range; adjust the A.C. ZERO control to bring the meter pointer to zero.
(7) Vary the mains supply voltage by ± 6% and note the change in meter reading, allowing time for it to become stable.
(8) If the meter reading increases with increase in mains supply voltage move the slider of RV7 downwards, i.e. towards the 220-kΩ resistor R23.
(9) If the meter reading decreases with increase in mains supply voltage, move the slider of RV7 upwards. (See Section 5.7 for information regarding cementing of potentiometer sliders.)
(10) Repeat operation (4) and readjust the A.C. ZERO control to return the meter pointer to zero.
(11) Repeat operations (7) to (10) until the change in meter zero, for a 6% mains supply voltage variation, is at a minimum. This should not be greater than ± 3% of full-scale deflection.
(12) Remove the short-circuit across R19.

5.8.5 D.C. CALIBRATION

(*Apparatus required: Item c*)

Full-scale deflection on the d.c. ranges is set up by adjustment of preset potentiometers RV1, RV2, and RV5. The procedure is as follows:—

(1) Set the Voltmeter zero as described in Section 2.4.1.
(2) Turn the Voltmeter Selector switches to the 300V " + " d.c. range, and connect the D.C./Ω probe and COMMON lead to the standardized source of 300 volts d.c., observing the conditions stated in Section 2.4.2.
(3) Adjust preset potentiometer RV1 to bring the meter pointer to full-scale deflection. (See Section 5.7 for information regarding cementing of potentiometer sliders.)
(4) Disconnect the 300-volt source and turn the right-hand Selector switch to " — " d.c., and reconnect the 300-volt source with reversed polarity.
(5) Note the Voltmeter reading.
(6) Readjust RV1 to equalize any error in full-scale deflection between the " + " and " — " d.c. positions.
(7) Reduce the standardized source voltage to 100 volts, and turn the left-hand Voltmeter Selector switch to 100V.

(8) Adjust preset potentiometer RV2 to bring the meter pointer to full-scale deflection.
(9) Check the meter deflection for a reversed polarity input and equalize any errors as before.
(10) Reduce the standardized source voltage to 3 volts and turn the Voltmeter Selector switch to 3V.
(11) Adjust the preset potentiometer RV5 to bring the meter pointer to full-scale deflection.
(12) Check the meter deflection for a reversed polarity input and equalize any errors as before.
(13) With appropriate values of voltage from the standardized voltage source, check that the Voltmeter indication is accurate to within $\pm 2\%$ of f.s.d. on the 3-, 10-, 30-, 100-, and 300-volt ranges.

5.8.6 D.C. PROBE INPUT RESISTANCE

(Apparatus required: Item d)

Measure the d.c. input resistance between the D.C./Ω probe and COMMON lead as follows:—

(1) Disconnect the Voltmeter from the mains supply and set the Selector switches to the 300V " + " d.c. range.
(2) Measure the resistance between the D.C./Ω probe and COMMON lead; this should be 90 MΩ $\pm 5\%$.

5.8.7 A.C. CALIBRATION

(Apparatus required: Item e)

Full-scale deflection on the a.c. ranges is set up by means of preset potentiometers RV3 and RV6. The adjustment procedure is as follows:—

(1) Short circuit the A.C. probe and COMMON lead and set zero as described in Section 2.3.1.
(2) Set the Voltmeter Selector switches to 100V A.C.
(3) Connect the A.C. probe to the 1000-c/s standardized source of 100 volts r.m.s., observing the conditions stated in Section 2.3.2.
(4) Adjust preset potentiometer RV3 to bring the meter pointer to full-scale deflection.
(5) Disconnect the 1000-c/s voltage source. Turn the left-hand Selector switch to 1V, recheck the Voltmeter zero setting, and readjust the SET ZERO control if necessary.
(6) Connect the a.c. probe to the 1000-c/s standardized voltage source of 1 volt r.m.s.
(7) Adjust preset potentiometer RV6 to give full-scale deflection on the meter. (See Section 5.7 for information regarding cementing of potentiometer sliders.)
(8) With appropriate values of voltage from the 1000-c/s standardized voltage source, check that the Voltmeter indication is accurate to within $\pm 3\%$ of f.s.d. $\pm 0{\cdot}02$ volts on the 1-, 3-, 10-, 30-, and 100-volt ranges.

5.8.8 A.C. INPUT IMPEDANCE

(Apparatus required: Item f)

Impedance at r.f.

The equivalent shunt resistance and the shunt capacitance presented by the A.C. probe to the unknown voltage source can be determined by the following procedure:—

(1) Set the Q-meter (Item f) to the frequency at which the input impedance is to be measured. Connect an appropriate inductor across the INDUCTOR terminals, i.e. an inductor to give resonance at this frequency.
(2) Turn the Q-meter to resonance; measure the magnification factor, Q_1, of the inductor, and note the reading C_1 on the capacitance dial.
(3) Set the Voltmeter right-hand Selector switch to A.C. and connect the probe across the CAPACITOR terminals of the Q-meter.
(4) Retune the Q-meter to resonance. The change in capacitance required will be approximately 4 μμF, i.e. the input shunt capacitance of the probe.
(5) Note the new value of the magnification factor, Q_2. The input shunt resistance, R_p of the Voltmeter is given by the expression

$$R_p\ k\Omega = \frac{159{\cdot}3}{f.C_1} \times \frac{Q_1.\ Q_2}{Q_1 - Q_2}$$

where the frequency f is in Mc/s, and C_1 is in μμF.

Impedance at l.f.

At l.f. the probe input impedance can be regarded as a pure resistance. Since its actual value at l.f. is of minor significance, and is also relatively difficult to measure accurately, the following procedure will give an indication as to whether or not the input impedance is of correct value.

(1) Connect a 3-MΩ resistor in series with the probe and then connect the resultant circuit to a video oscillator.
(2) Note the Voltmeter reading with the added resistance (i) in circuit, and (ii) short circuited.

If the true input resistance is greater than 5 MΩ the rise in Voltmeter reading when the 3-MΩ resistor is short circuited will be less than 2: 1.

5.8.9 FREQUENCY RESPONSE

(Apparatus required: Items g, h, i, and j)

Set the Voltmeter Selector switches to 1V A.C.

Connect the output of the video oscillator (Item g) to the Voltmeter a.c. probe and to the input of the standardized reference voltmeter (Item i).

Adjust the video oscillator to give a frequency of 10 Mc/s at a level which produces a convenient meter deflection, say 0·6 volt, on the Voltmeter. Note the reading on the reference voltmeter.

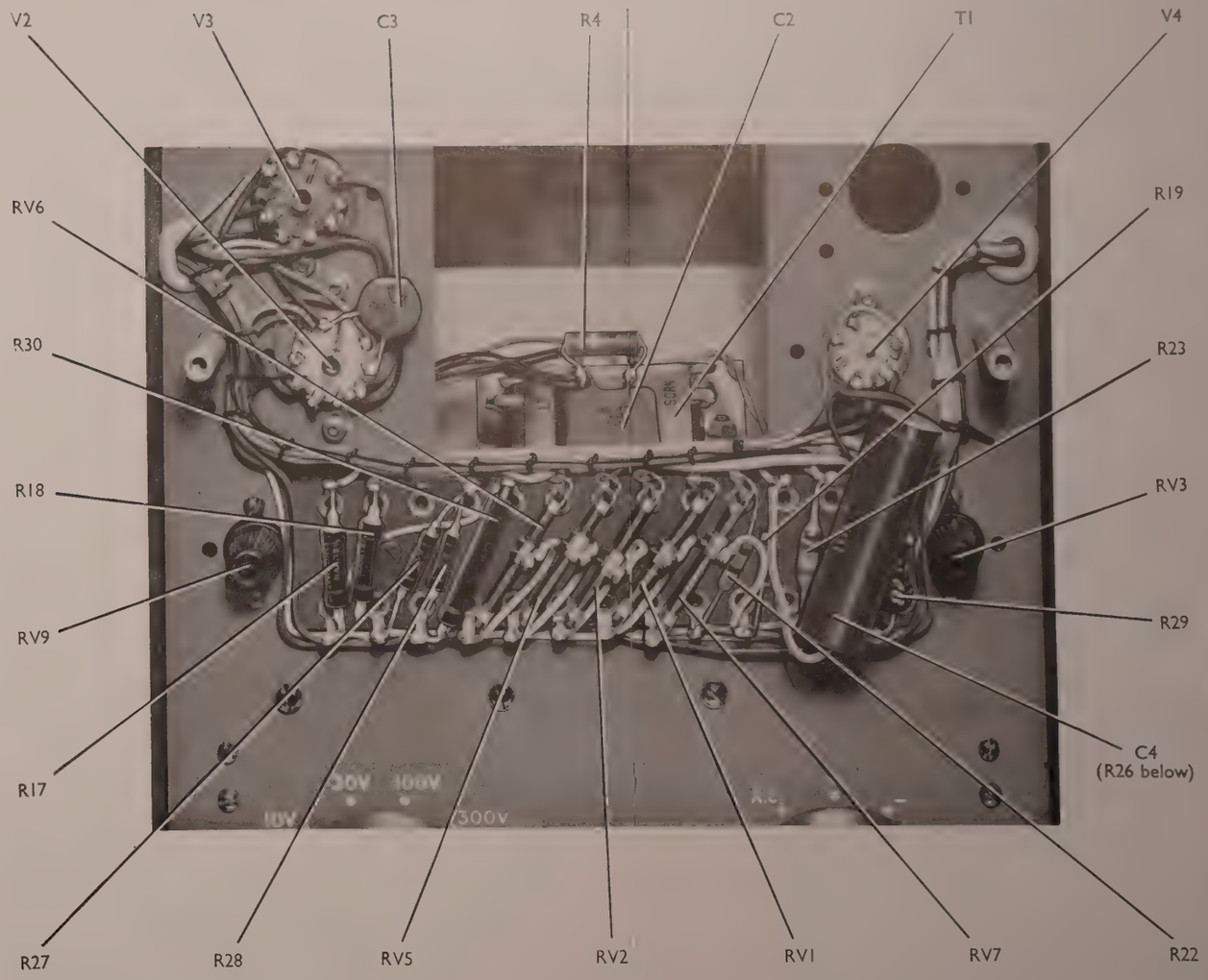
(4) Vary the frequency in steps down to 20 c/s, readjusting the video oscillator output for a constant meter deflection on the TF 1300, and noting the reading on the reference voltmeter.

(5) Standardize the crystal voltmeter (Item j) against the reference voltmeter at 10 Mc/s, and use the former in conjunction with the signal generator (Item h) to check the frequency response from 10 to 300 Mc/s.

A typical frequency characteristic, relative to 1 kc/s, is flat to within $\pm 0{\cdot}2$ dB from 50 c/s to 200 Mc/s, falling to within -1dB at 20 c/s, and rising to within $+1{\cdot}5$ dB at 300 Mc/s—see Fig. 2.2 on page 7.

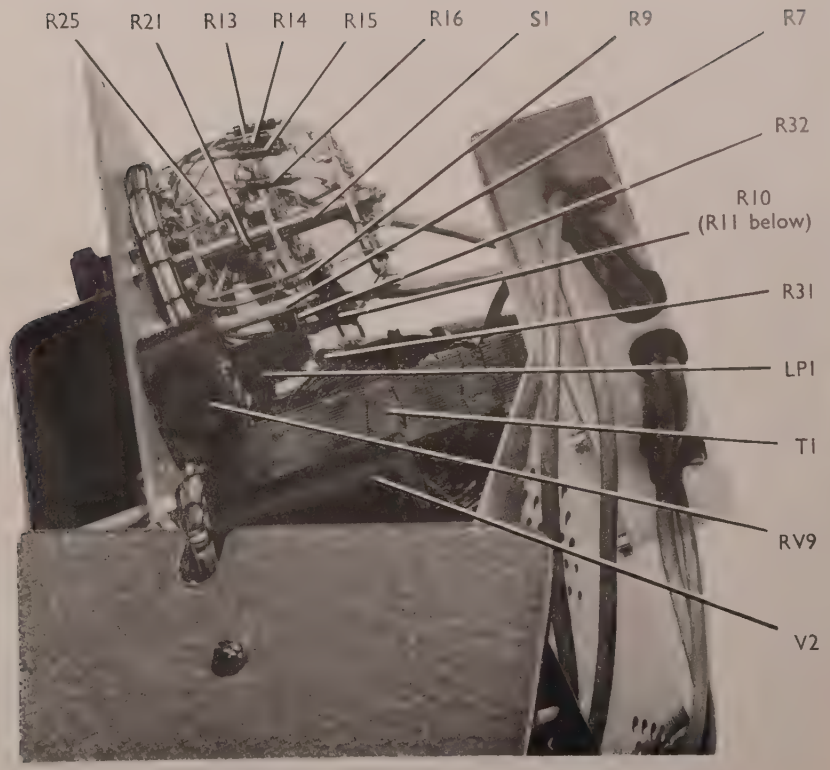
5.8.10 RESISTANCE CALIBRATION

With the Voltmeter set to measure resistance as described in Section 2.5 check that, for both resistance ranges, sensibly accurate indications are obtained when known values of resistance are connected between the D.C./Ω probe and the COMMON lead.

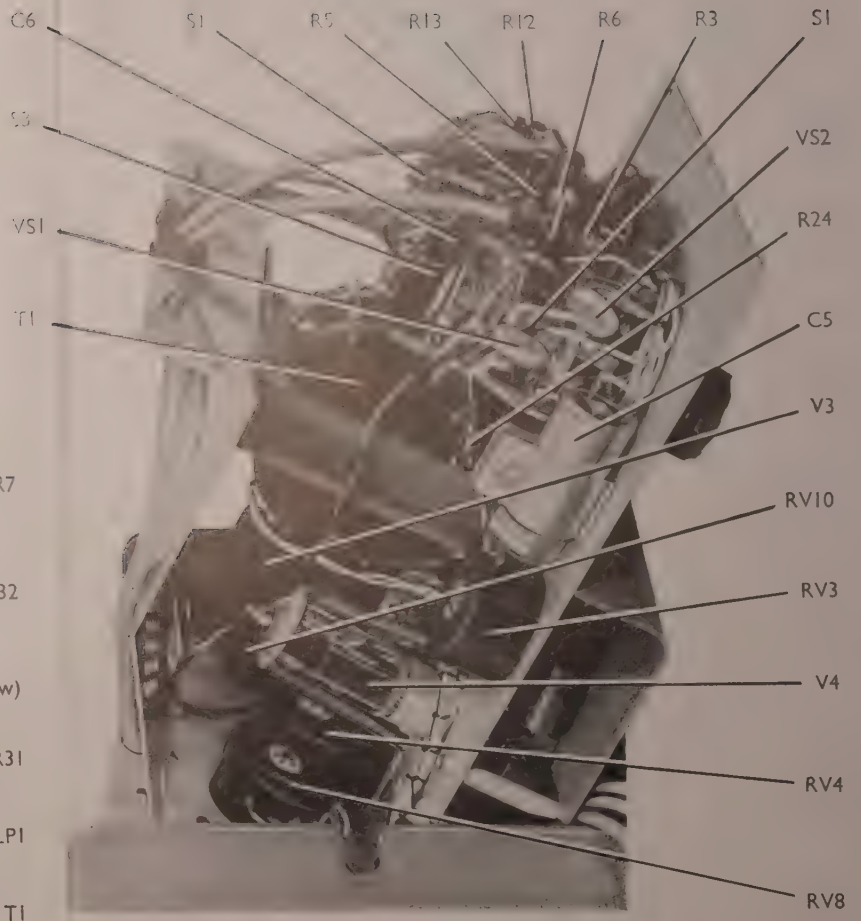


FRONT
WITH METER SURROUND REMOVED

Fig. 6.1



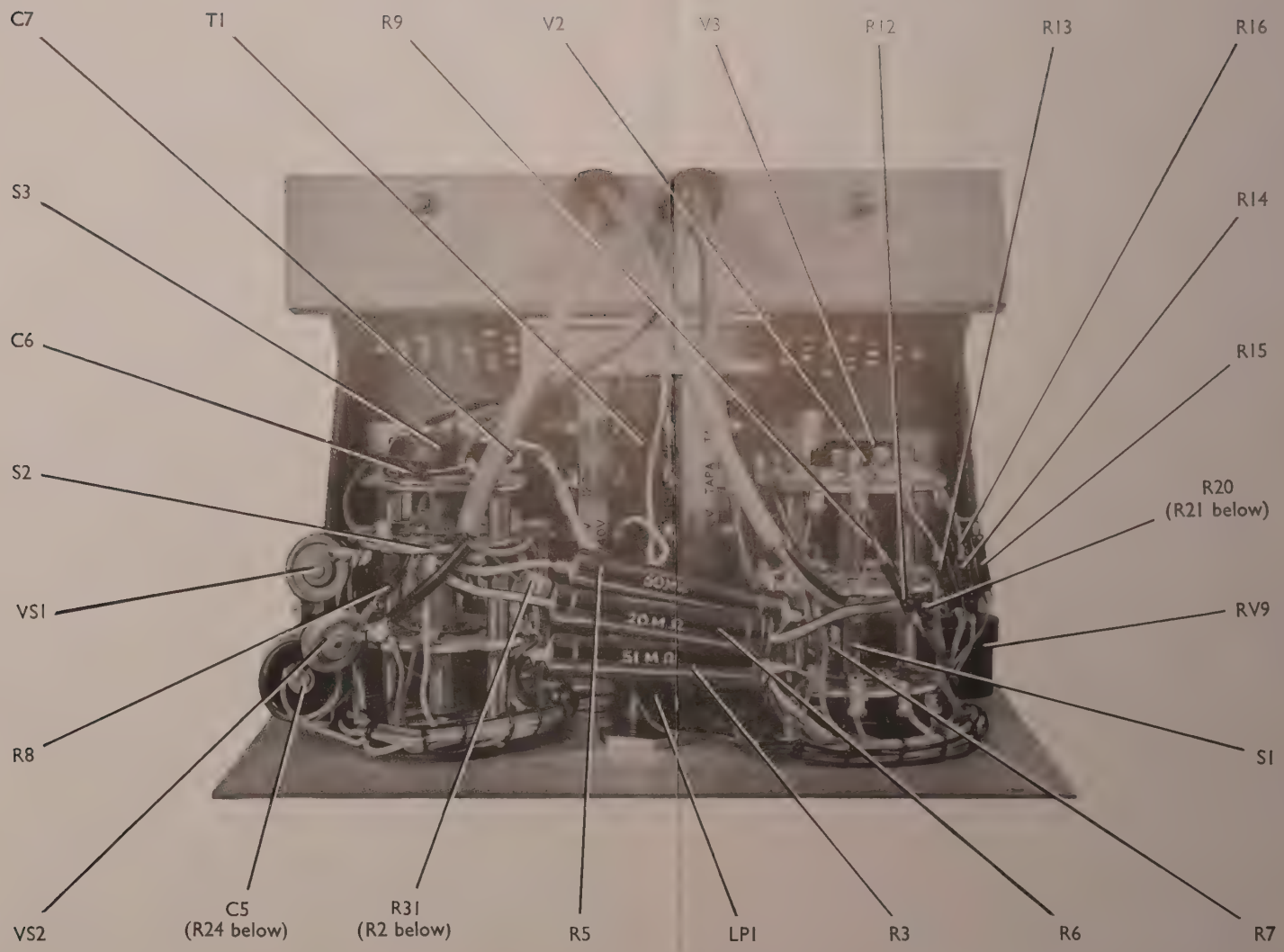
INTERIOR VIEW FROM LEFT



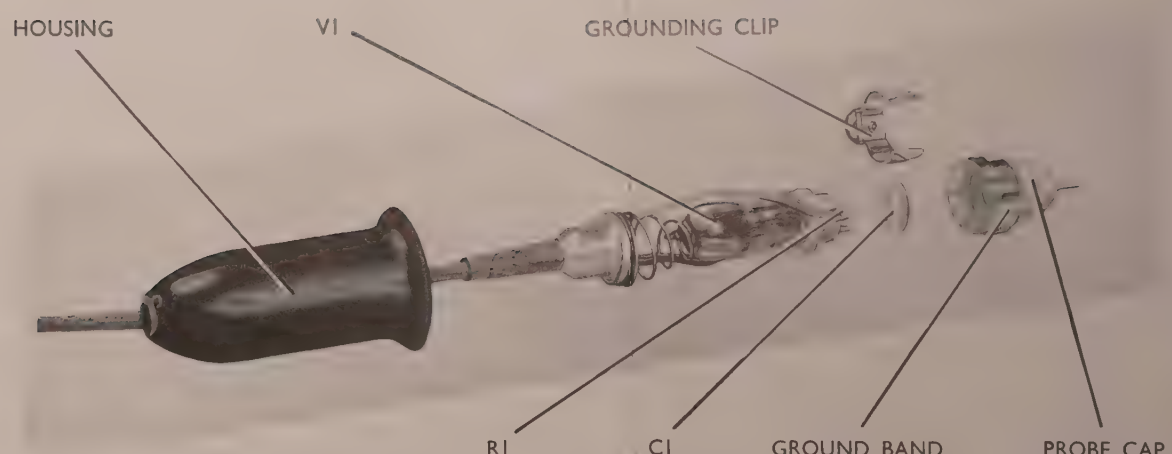
INTERIOR VIEW FROM RIGHT

INTERIOR VIEWS

Fig. 6.2



INTERIOR VIEW FROM TOP



PROBE UNIT

Fig. 6.4

7 Spares Ordering Schedule
No. SOS/1300

for VACUUM TUBE VOLTMETER, TYPE TF 1300

When ordering replacement parts, always quote the TYPE NUMBER and SERIAL NUMBER of the instrument, the QUANTITY required and the appropriate SOS ITEM NUMBER.

For example, to order replacements for the 7·5-MΩ resistor, R2, and the 0·25-μF capacitor, C4, quote as follows:—

Spares required for TF 1300, *Serial No.* 000000
1 off, SOS Item 2
1 off, SOS Item 46

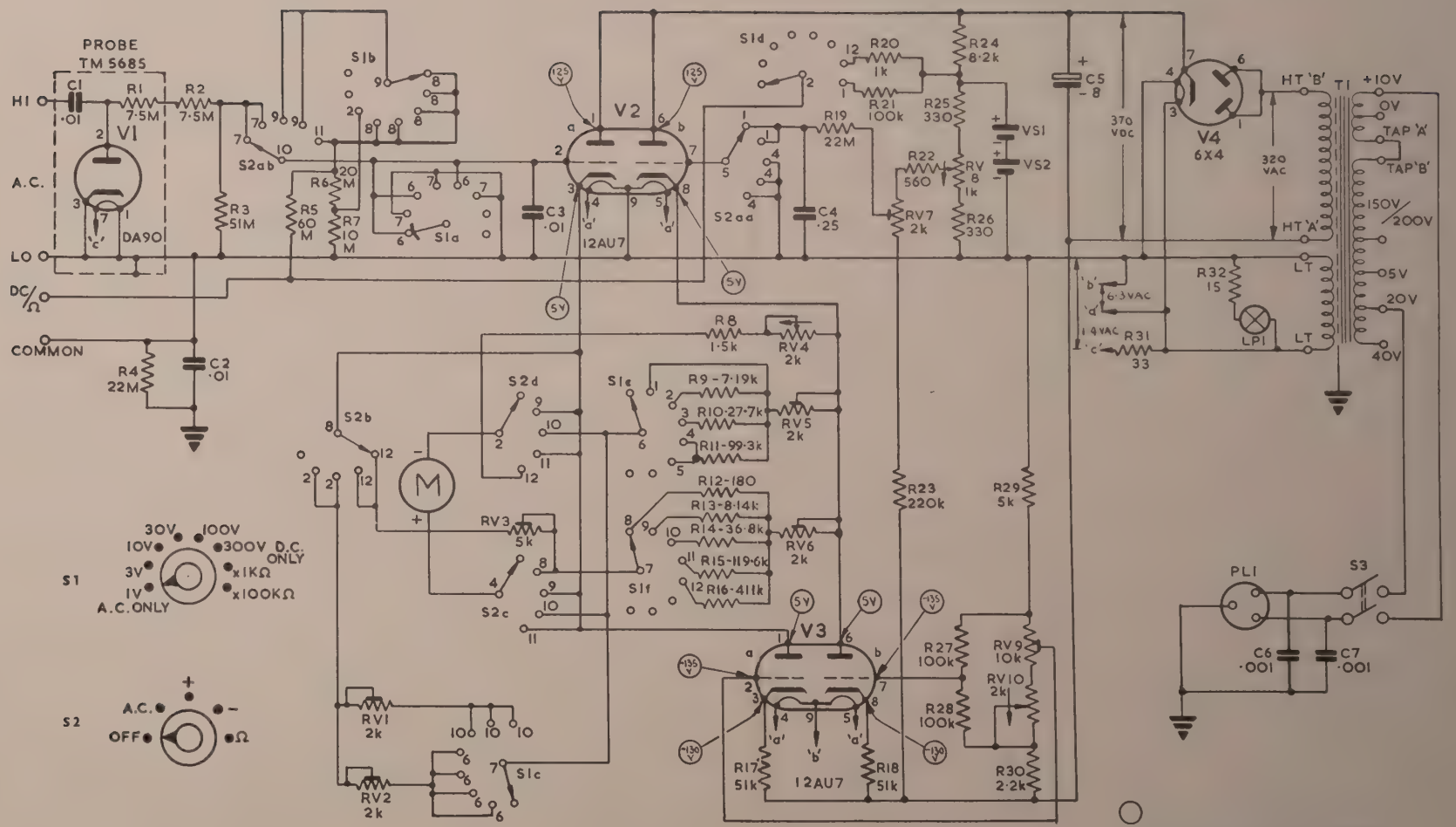
It is important that the distinguishing code " SOS " preceding each item number should not be omitted.

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		FIXED RESISTORS	
1	R1	Composition, 7·5 MΩ ± 5%, ½ W, included in Item 76.	16–TM5685
2	R2	Composition, 7·5 MΩ ± 5%, ½ W.	45–TF1300
3	R3	Carbon High Stability, 51 MΩ ± 5%, 2 W.	46–TF1300
4	R4	Composition, 22 MΩ ± 20%, 1 W.	60–TF1300
5	R5	Carbon High Stability, 60 MΩ ± 5%, 2 W.	48–TF1300
6	R6	Carbon High Stability, 20 MΩ ± 1%, 2 W.	47–TF1300
7	R7	Carbon High Stability, 10 MΩ ± 5%, ½ W.	49–TF1300
8	R8	Composition, 1·5 kΩ ± 10%, ½ W.	64–TF1300
9	R9	Carbon High Stability, 7·19 kΩ ± 1%, ¼ W.	55–TF1300
10	R10	Carbon High Stability, 27·7 kΩ ± 1%, ¼ W.	56–TF1300
11	R11	Carbon High Stability, 99·3 kΩ ± 1%, ¼ W.	57–TF1300
12	R12	Carbon High Stability, 180 Ω ± 1%, ¼ W.	50–TF1300
13	R13	Carbon High Stability, 8·14 kΩ ± 1%, ¼ W.	51–TF1300
14	R14	Carbon High Stability, 36·8 kΩ ± 1%, ¼ W.	52–TF1300
15	R15	Carbon High Stability, 119·6 kΩ ± 1%, ¼ W.	53–TF1300
16	R16	Carbon High Stability, 411·0 kΩ ± 1%, ¼ W.	54–TF1300
17	R17	Carbon High Stability, 51 kΩ ± 2%, ½ W.	2–TM5686
18	R18	Carbon High Stability, 51 kΩ ± 2%, ½ W.	3–TM5686
19	R19	Composition, 22 MΩ ± 10%, ½ W.	13–TM5686
20	R20	Carbon High Stability, 1kΩ ± 1%, ¼ W.	58–TF1300
21	R21	Carbon High Stability, 100 kΩ ± 1%, ¼ W.	63–TF1300
22	R22	Composition, 560 Ω ± 5%, ½ W.	12–TM5686
23	R23	Composition, 220 kΩ ± 10%, ½ W.	14–TM5686
24	R24	Carbon High Stability, 8·2 kΩ ± 5%, 2 W.	59–TF1300
25	R25	Composition, 330 Ω ± 10%, ½ W.	65–TM5686

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
26	R26	Composition, 330 Ω ± 10%, ½ W.	15–TM5686
27	R27	Carbon High Stability, 100 kΩ ± 5%, ¼ W.	4–TM5686
28	R28	Carbon High Stability, 100 kΩ ± 5%, ¼ W.	5–TM5686
29	R29	Carbon High Stability, 5 kΩ ± 5%, 1 W.	16–TM5686
30	R30	Carbon High Stability, 2·2 kΩ ± 5%, ¾ W.	6–TM5686
31	R31	Composition, 33 Ω ± 5%, 1 W.	61–TF1300
32	R32	Composition, 15 Ω ± 10%, ½ W.	62–TF1300
		VARIABLE RESISTORS	
33	RV1	Wirewound, 2 kΩ ± 10%, ½ W, Linear.	10–TM5686
34	RV2	Wirewound, 2 kΩ ± 10%, ½ W, Linear.	9–TM5686
35	RV3	Wirewound, 5 kΩ ± 10%, 3 W, Linear.	40–TF1300
36	RV4	Wirewound, 2 kΩ ± 10%, 3 W, Linear.	39–TF1300
37	RV5	Wirewound, 2 kΩ ± 10%, ½ W, Linear.	8–TM5686
38	RV6	Wirewound, 2 kΩ ± 10%, ½ W, Linear.	7–TM5686
39	RV7	Wirewound, 2 kΩ ± 10%, ½ W, Linear.	11–TM5686
40	RV8	Wirewound, 1 kΩ ± 10%, 3 W, Linear.	41–TF1300
41	RV9	Wirewound, 10 kΩ ± 10%, 3 W, Linear.	38–TF1300
42	RV10	Wirewound, 2 kΩ ± 10%, 3 W, Linear.	39–TF1300
		CAPACITORS	
43	C1	Ceramic, 0·01 μF + 80 — 20%, 350 V d.c., included in Item 76.	19–TM5685
44	C2	Paper, 0·01 μF ± 25%, 1000 V d.c.	71–TF1300
45	C3	Ceramic, 0·01 μF + 80% — 20%, 350 V d.c.	69–TF1300
46	C4	Paper, 0·25 μF ± 20%, 200 V d.c.	70–TF1300
47	C5	Electrolytic, 8 μF + 50% — 20%, 450 V d.c.	PC18406/2
48	C6	Paper, 0·001 μF ± 20%, 600 V d.c.	72–TF1300
49	C7	Paper, 0·001 μF ± 20%, 600 V d.c.	72–TF1300
		TRANSFORMER	
50	T1	Mains Transformer.	TM5149/6
		SWITCHES	
51	S1	Rotary, 6-pole, 8-position, 3-wafer.	TC4428/464
52	S2/S3	Rotary, 5-pole, 5-position, 2-wafer with double-pole ON/OFF switch.	TC4428/465

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		VALVES, VALVE HOLDERS AND RETAINERS	
53	V1	DA90 Diode, included in Item 76.	30–TM5685
54		Holder for V1, Special B7G, included in Item 76.	TB27964
55		Retaining Spring for V1, included in Item 76.	27–TM565
56	V2	12AU7 Double Triode.	81–TF1300
57		Holder for V2, B9A, with skirt.	33–TF1300
58		Screening Can, for V2.	PC17502/2
59	V3	12AU7 Double Triode.	81–TF1300
60		Holder for V3, B9A, with skirt.	32–TF1300
61		Screening Can, for V3.	PC17502/2
62	V4	6X4 Full-wave Rectifier.	82–TF1300
63		Holder for V4, B7G, non-skirted.	31–TF1300
64		Retainer, for V4.	35–TF1300
		VOLTAGE STABILIZERS	
65	VS1	Voltage Stabilizer, 1·5-volt, A.E. 15BC20.	75–TF1300
66	VS2	Voltage Stabilizer, 1·5-volt, A.E. 15BC20.	75–TF1300
		PILOT LAMP AND HOLDER	
67	LP1	6·3-volt, 0·15-amp, M.C.C. Tubular.	85–TF1300
68		Holder for LP1, M.C.C.	TB25073/2
		METER	
69	M1	0–200 μA, 500 Ω, Moving Coil Meter.	TM3970/76
		KNOBS	
70		Knob, for Left- or Right-hand Selector Switch.	TB17848/3
		PLUGS, LEADS AND CONNECTORS	
71		Mains Lead, comprising 6-ft, 3-core, flexible cable and 3-pin plug.	TM2560/AQ
72		Mains Plug, 3-pin, 5-amp, included in Item 71.	1–TM2560/AQ
		SUB-ASSEMBLIES	
73		COMMON Lead Assembly, including Items 74 and 75.	TB27956
74		Crocodile Clip, for use with and included in Item 73.	TB27958
75		P.V.C. Moulding for use with and included in Item 73.	TB27959
76		Complete A.C. Probe Assembly, including Items 1, 43, 53, 54, 55, and 77 to 84.	TM5685
77		Polythene Nose Moulding, complete with probe needle bush, included in Item 76.	TC27135/1

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
78		Threaded Nose Body, included in Item 76.	TB27969
79		Probe Needle, to fit Item 77, included in Item 76.	TE23531/14
80		Probe Case, included in Item 76.	TC27950
81		Connecting Lead, twin-core, screened, anti-microphonic cable, 48 inches long, included in Item 76.	9–TM5685
82		P.V.C. Moulding, Red, to fit over Item 80, included in Item 76.	TC27951
83		Cable Grommet, to fit over Item 81, included in Item 76.	10–TM5685
84		Grounding Clip Assembly, included in Item 76.	TC23535/3
85		Complete D.C./Ω Probe Assembly, including Items 86 to 88.	TB27957
86		Prod Clip, included in Item 85.	80–TF1300
87		P.V.C. Moulding, Grey, included in Item 85.	79B–TF1300
88		Connecting Lead, 3-core, 48 inches long, included in Item 85.	79A–TF1300
		MISCELLANEOUS	
89		Meter Surround Panel.	TC27949
90		Lid Clip, to fit Item 89.	TB27960
91		Front Panel.	TE27942
92		Side Panels, left or right.	TC27948
93		Case Lid.	TC27947
94		Case Back.	TE27943
95		Screening Panel.	TD27944
96		Plastic Clip, for securing leads to screening panel.	24–TF1300
97		Capacitor Clip, for C5.	25–TF1300
98		Meter Spacer, to fit between rear of meter and front panel.	TB27954
99		Set of two Hexagonal Wrenches, for socket screws, sizes 2 BA ($\frac{3}{32}$ in. a/f) and 4 BA ($\frac{1}{16}$ in. a/f), complete in linen bag.	
100		Operating and Maintenance Handbook.	OM1300
		OPTIONAL ACCESSORIES	
101		A.C. Multiplier.	TM6067



Valve electrode voltages measured with respect to chassis (see Section 5.4).

CIRCUIT DIAGRAM

9 Decibel Conversion Table

Ratio Down			Ratio Up	
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER
1·0	1·0	**0**	1·0	1·0
·9886	·9772	**·1**	1·012	1·023
·9772	·9550	**·2**	1·023	1·047
·9661	·9333	**·3**	1·035	1·072
·9550	·9120	**·4**	1·047	1·096
·9441	·8913	**·5**	1·059	1·122
·9333	·8710	**·6**	1·072	1·148
·9226	·8511	**·7**	1·084	1·175
·9120	·8318	**·8**	1·096	1·202
·9016	·8128	**·9**	1·109	1·230
·8913	·7943	**1·0**	1·122	1·259
·8710	·7586	**1·2**	1·148	1·318
·8511	·7244	**1·4**	1·175	1·380
·8318	·6918	**1·6**	1·202	1·445
·8128	·6607	**1·8**	1·230	1·514
·7943	·6310	**2·0**	1·259	1·585
·7762	·6026	**2·2**	1·288	1·660
·7586	·5754	**2·4**	1·318	1·738
·7413	·5495	**2·6**	1·349	1·820
·7244	·5248	**2·8**	1·380	1·905
·7079	·5012	**3·0**	1·413	1·995
·6683	·4467	**3·5**	1·496	2·239
·6310	·3981	**4·0**	1·585	2·512
·5957	·3548	**4·5**	1·679	2·818
·5623	·3162	**5·0**	1·778	3·162
·5309	·2818	**5·5**	1·884	3·548
·5012	·2512	**6**	1·995	3·981
·4467	·1995	**7**	2·239	5·012
·3981	·1585	**8**	2·512	6·310
·3548	·1259	**9**	2·818	7·943
·3162	·1000	**10**	3·162	10·000
·2818	·07943	**11**	3·548	12·59
·2512	·06310	**12**	3·981	15·85
·2239	·05012	**13**	4·467	19·95
·1995	·03981	**14**	5·012	25·12
·1778	·03162	**15**	5·623	31·62

DECIBEL CONVERSION TABLE

Ratio Down			*Ratio Up*	
VOLTAGE	*POWER*	*DECIBELS*	*VOLTAGE*	*POWER*
·1585	·02512	**16**	6·310	39·81
·1413	·01995	**17**	7·079	50·12
·1259	·01585	**18**	7·943	63·10
·1122	·01259	**19**	8·913	79·43
·1000	·01000	**20**	10·000	100·00
·07943	·006310	**22**	12·59	158·5
·06310	·003981	**24**	15·85	251·2
·05012	·002512	**26**	19·95	398·1
·03981	·001585	**28**	25·12	631·0
·03162	·001000	**30**	31·62	1,000
·02512	·0006310	**32**	39·81	1,585
·01995	·0003981	**34**	50·12	2,512
·01585	·0002512	**36**	63·10	3,981
·01259	·0001585	**38**	79·43	6,310
·01000	·0001000	**40**	100·00	10,000
·007943	·00006310	**42**	125·9	15,850
·006310	·00003981	**44**	158·5	25,120
·005012	·00002512	**46**	199·5	39,810
·003981	·00001585	**48**	251·2	63,100
·003162	·00001000	**50**	316·2	100,000
·002512	$6{\cdot}310 \times 10^{-6}$	**52**	398·1	158,500
·001995	$3{\cdot}981 \times 10^{-6}$	**54**	501·2	251,200
·001585	$2{\cdot}512 \times 10^{-6}$	**56**	631·0	398,100
·001259	$1{\cdot}585 \times 10^{-6}$	**58**	794·3	631,000
·001000	10^{-6}	**60**	1,000	10^{6}
·0005623	$3{\cdot}162 \times 10^{-7}$	**65**	1,778	$3{\cdot}162 \times 10^{6}$
·0003162	10^{-7}	**70**	3,162	10^{7}
·0001778	$3{\cdot}162 \times 10^{-8}$	**75**	5,623	$3{\cdot}162 \times 10^{7}$
·0001000	10^{-8}	**80**	10,000	10^{8}
·00005623	$3{\cdot}162 \times 10^{-9}$	**85**	17,780	$3{\cdot}162 \times 10^{8}$
·00003162	10^{-9}	**90**	31,620	10^{9}
·00001000	10^{-10}	**100**	100,000	10^{10}
$3{\cdot}162 \times 10^{-6}$	10^{-11}	**110**	316,200	10^{11}
10^{-6}	10^{-12}	**120**	10^{6}	10^{12}
$3{\cdot}162 \times 10^{-7}$	10^{-13}	**130**	$3{\cdot}162 \times 10^{6}$	10^{13}
10^{-7}	10^{-14}	**140**	10^{7}	10^{14}

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